TR-154

TECHNICAL REPORT

HARBOR ANALOG SYSTEM
PART II—TEMPERATURE STRUCTURE

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ABSTRACT

This report classifies harbor areas having similar water temperature characteristics. The principal predictor is the mean monthly air temperature at locations throughout the world. A system of classification based primarily on the continentality of the area is presented. Factors which cause anomalies from the general case are large tidal ranges and fresh water discharge from rivers. Within each class, the mean air-water temperature difference at the surface (near the shore) is presented with standard deviations from the mean difference for each month. In addition, data showing vertical thermal gradients from the shore seaward are presented for the various classes by season.

ERRATA TO TR-154, PART II-TEMPERATURE STRUCTURE

p.	3	footnote*	line 2, read--current information is not--
			line 9, read--(reference no. 21) are--
p.	4	footnote*	line 1, read--the Arctic and--
			line 5, read--(reference nos. 26 and 27).--
p.	12		lines 3, 15, and 18, change reference No. 20 to reference No. 19.
			line 16, read--.06 to .38**--
p.	14		lines 10 and 11, read--references 4, 5, 6, 10, 11, 15, 18, 19, and 25.

FOREWORD

This report is a contribution of the Harbor Analog System program being pursued by the U. S. Naval Oceanographic Office. Additional reports will follow as classification systems are developed for other oceanographic characteristics of harbor and nearshore areas.

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INTRODUCTION

There are considerable published data concerning the factors which affect the surface water temperatures of the oceans, the transport of heat, and temperature change in the upper layers of the ocean. After all of the physical and dynamic processes relating environmental factors such as evaporation, radiation, cloudiness, wind velocity and turbulence are considered, the useful generality is that a high correlation between surface air and water temperature can be shown. This correlation, better in low latitudes where annual ranges of temperature are small, decreases toward higher latitudes. Since fresh water freezes at 32°F. and highly saline waters freeze at temperatures between 28° and 29°F., it is apparent that mean air temperatures which are colder than the sea surface freezing points may differ considerably from the water temperatures; however, the utility of mean air temperatures in forecasting water temperatures remains high because mean air temperatures below 28°F. for a period of several days will produce ice or water temperatures in the range between 28° and 32°F.

Since one of the main objectives of this report is to estimate the surface water temperature in any harbor on earth, it was thought that the use of H.O. Publication No. 225, "World Atlas of Sea Surface Temperatures." would be useful in approximating the surface temperature in nearshore waters. However, comparison of U. S. Coast and Geodetic Survey tide-station temperatures with the isotherms in this publication revealed these isotherms to be unreliable in nearshore areas. In contrast, comparison of mean air temperatures from the "U. S. Navy Marine Climatic Atlas of the World" with surface water temperatures for the U. S. Coast and Geodetic Survey tide stations indicated a high correlation between the mean monthly air temperature and the average nearshore surface water temperature for the same month. The air-sea temperature difference is least in low latitudes where the annual range of mean monthly air temperature is small and becomes greater in higher latitudes where the annual range of air temperature increases. The average differences were relatively variable where the surface water temperature was influenced by fresh water river discharge or where tidal ranges were high. Inland water areas such as the harbors

of Baltimore and Philadelphia showed equally high correlations between mean air temperature and surface water temperature when the mean air temperature data were taken at the same location as the surface water temperature data. Local temperature data from climatic summaries of the Weather Bureau or similar sources should be used for inland air temperature data because landward extension of isotherms from marine atlases do not reflect the land-sea thermal discontinuity.

In areas where cold currents, warm currents, or upwelling are persistent, the water temperature modifies air temperatures so that climatic air temperature data reflect these phenomena. These factors do not cause anomalies from the general case; however, high tidal ranges and fresh water river discharge are phenomena which do present anomalies in air-water temperature differences from the general case of low turbulence and homogeneous salinity. It is very possible that upwelling and thermal current advection may cause anomalous situations from the general vertical thermal structure. However, in this preliminary system development, it is deemed impractical to use upwelling and thermal advection currents in the classification system.

CLASSIFICATION SYSTEM

By using the CLASSIFICATION INDEX which follows, it is possible to classify any harbor in the world according to the following criteria:

(a) Mean air temperature in the warmest and coldest months,
(b) An index of continentality as determined by the annual range of mean monthly air temperature,
(c) Tidal range, and
(d) Presence or absence of fresh water discharge.

Turbulence influenced by winds and waves, the volume of river discharge, the bottom slope, the depth of water, and other minor influences probably cause some anomalies from the general case of low turbulence and homogeneous salinity. Such environmental influences were considered too trivial or impractical to incorporate into a general system of classification. Upwelling and horizontal thermal advection currents are presumed to be reflected in the mean air temperature for any location and are not regarded as classification items.

The necessary tools needed to classify a harbor according to this system are the following:

(1) Mean air temperatures for each month. (Figures 1 to 12)*
(2) Tide range tables or charts (Figure 13)**
(3) Hydrographic charts or maps indicating the presence or absence of fresh water influence.

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*Mean air temperatures from Figures 1 through 12 should be used only when a more detailed atlas or current information are not available. Actual averages of air temperatures for two weeks to a month prior to the forecast date should be used whenever possible. U. S. Weather Bureau data and averaging techniques should give optimum results if the air temperature data are representative of the vicinity of the forecast point. Climatic data from U. S. Weather Bureau, foreign climatic tables and atlases, and "U. S. Navy Marine Climatic Atlases" (Vols. I-V) (reference no. 25) are recommended when current information is not available.

**Figure 13 should be used when tide tables or suitable tide range analysis is not available.

CLASSIFICATION INDEX

1. First Designator: The first two numerals indicate the mean air temperature to the nearest 1°F. for the coldest month of the year (usually January or February in the Northern Hemisphere and July or August in the Southern Hemisphere).

2. Second Designator: The second two numerals indicate the mean air temperature to the nearest 1°F. for the warmest month of the year (July or August in the Northern Hemisphere, January or February in the Southern Hemisphere).

3. Third Designator: The difference between the first and second designators is an indication of continentality. The Third Designator is taken from the following table.

CONTINENTALITY CLASS	ANNUAL RANGE OF MEAN MONTHLY AIR TEMPERATURE
T - Tropic	Less than 6°F.
O - Oceanic	6° to 14°F.
S - Sub-Continental	15° to 35°F.
C - Continental	Greater than 35°F.
A - Arctic	Greater than 50°F.*

*The annual range of mean monthly temperature in the Artic and Antarctic is generally greater than 50°F. Water temperatures, air-sea temperature differences, ice location and limits, and typical vertical thermal structure of the water should be obtained from H. O. Pub. No. 705, "Oceanographic Atlas of the Polar Seas" (reference no. 26).

4. Fourth Designator: Tidal Range

L: Less than 10 feet
H: 10 feet or greater

5. Fifth Designator:

N: Area not affected by river (fresh water) discharge.
R: Area affected by river (fresh water) discharge.

An example of the use of the CLASSIFICATION INDEX is given for Los Angeles. The coldest mean monthly air temperature (See Figures 1 to 12) is 55° in January. The warmest mean monthly air temperature is 68°F. in July. The tide range as shown by Figure 13 is less than 10 feet. Available maps show that no fresh water discharge affects this area. The 13°F. temperature difference between 68°F. and 55°F. places this location in the Oceanic Climate Class. The coded designation of this area, 5568OLN, identifies the harbor class. With the mean air-water temperature difference (See Table II) for an OLN class and the typical winter and summer vertical temperature differences from the surface temperature (See Table VI) for OLN class, an estimate of the surface water temperature (T_w or T_{ms}) is possible as well as an estimate of the 68% confidence interval through use of the standard deviation values from the means. Although information in the tables is compiled only for the warmest and coldest months, a suggested method of estimation of temperatures at the surface and depth for intermediate months is shown under PREDICTION EXAMPLE. It should be noted that the surface water temperature (T_w or T_{ms}) derived from Tables I to IV refers to the surface water very nearshore; whereas, the vertical differences are with respect to the surface water temperature (Tw_{30}) above the 30-fathom isobath. The surface water temperature above the 30-fathom isobath (Tw_{30}) can be estimated by adding the correction ($\bar{C}$) in Tables IX to XII to the nearshore surface water temperature (T_w or T_{ms}).

Since the $\bar{C}$ values in Tables IX to XIII do not present values for distances greater than 10 nautical miles from the shore, the $\bar{C}$ value at 10 nautical miles should be used to obtain (Tw_{30}) when the 30 fathom isobath is more than 10 miles offshore.

PREDICTION EXAMPLE

The following steps show how a forecast of water temperature is made for a harbor near New Orleans at the mouth of the Mississippi River.

STEP I

List the mean air temperature in this area by months from Figures 1 through 12 or from ''U. S. Navy Marine Climatic Atlas of the World.'' Estimate the air temperature to nearest 0.1°F.

MONTH	MEAN AIR TEMPERATURE (°F.)
Jan	60.0
Feb	60.0
Mar	64.0
Apr	69.8
May	72.5
Jun	81.8
Jul	82.0
Aug	83.2
Sep	82.5
Oct	77.0
Nov	68.0
Dec	63.0

STEP II

Note the coldest month (January and February) to the nearest degree and assign the First Designator from the Classification Index. (60)

STEP III

Note the warmest month (August) to the nearest degree and assign the Second Designator from the Classification Index. (83)

STEP IV

Subtract the First Designator value from the value of the Second Designator to determine the Third Designator from the CLASSIFICATION INDEX. (23) This places the harbor in the Sub-Continental category

(S) according to the CLASSIFICATION INDEX on page 5.

STEP V

Consult tide tables or Figure 13 to determine the tidal range in the harbor area and assign the Fourth Designator from the CLASSIFICATION INDEX. (L)

STEP VI

Consult a map or hydrographic chart to determine whether the harbor is under the influence of river (fresh water) discharge and assign the Fifth Designator from the CLASSIFICATION INDEX. (R). From the foregoing steps, this harbor area is classified as 6083SLR.

STEP VII

Using Table III and data from Step I, list the surface water temperature (T_w) and the 68% Confidence Interval of the surface water temperature for each month.

MONTH	T_a	$\bar{C} = (\bar{T}_w - \bar{T}_a)$	T_{ms} or T_w	σ_c	68% Confidence Interval
Jan	60.0	2.3	62.3	3.7	58.6 to 66.0
Feb	60.0	2.7	62.7	4.6	58.1 to 67.3
Mar	64.0	1.4	65.4	5.5	59.9 to 70.9
Apr	69.8	-0.1	69.7	3.3	66.4 to 73.0
May	75.2	-0.9	74.3	2.8	71.5 to 77.1
Jun	81.8	-1.1	80.7	3.2	77.5 to 83.9
Jul	82.0	0.0	82.0	2.7	79.3 to 84.7
Aug	83.2	0.9	84.1	3.0	81.1 to 87.1
Sep	82.5	0.5	83.0	2.1	80.9 to 85.1
Oct	77.0	0.5	77.5	2.0	75.5 to 79.5
Nov	68.0	2.5	70.5	2.5	68.0 to 73.0
Dec	63.0	2.4	65.4	3.4	62.0 to 68.8

STEP VIII

Using the most likely value of surface water temperature obtained in Step VII and the most likely vertical temperature differences at each depth for the coldest month (January) and the warmest month (August) from Table VII, the following estimates of the most likely temperatures (means) at various depths can be made:

Depth	Jan (°F)	Aug (°F)	Annual Range (°F)
Surface	62.3	84.1	21.8
10 feet	62.4	83.7	21.3
20 feet	62.5	83.2	20.7
30 feet	62.6	82.2	19.6
50 feet	62.6	79.9	17.3
70 feet	62.8	77.1	14.3
100 feet	62.7	72.1	9.4
150 feet	63.3	70.3	7.0
180 feet	63.5	70.0	6.5

STEP IX

An estimate of the temperatures at each depth may be made for the intermediate months of the year by assuming that the seasonal temperature change at each depth is proportional to the seasonal change at the surface. These estimates can be made by use of the following equation:

$$T_{md} = \frac{R_d}{R_s}(T_{ms} - T_{cs}) + T_{cd} \qquad \text{(Equation 1)}$$

where,

T_{md}=temperature at depth (d) for month (m)
R_d=annual range of temperature at depth (d)
R_s=annual range of temperature at surface
T_{ms}=temperature at the surface (s) for month (m)
T_{cs}=temperature at the surface (s) for coldest month (c), (January in this example)
T_{cd}=temperature at depth (d) for the coldest month (m) (January)

Using Equation 1, an estimate of the most likely temperature at the 10-foot depth in March is made as follows:

T_{cd}=62.4° (Coldest month, January temperature at 10 feet)

T_{cs}=62.3° (Coldest month, January temperature at the surface)

R_d/R_s=21.3/21.8=0.977

T_{ms}=65.4°

By substitution in Equation 1,

T_{md}=0.977(65.4° - 62.3°) + 62.4°=0.977(3.1°) + 62.4° =

3.03° + 62.4° = 65.43°

T_{md}=65.4° (Most likely temperature at 10 foot depth in March)

Similarly, an estimate for the 50-foot depth in March using Equation 1

T_{ms}=65.4° T_{cs}=62.3° T_{cd}=62.6°

R_d=17.3° R_s=21.8° R_d/R_s=17.3/21.8+=0.793

T_{md}=0.793 (65.4° - 62.3°) + 62.6°

T_{md}=0.793 (3.1°) + 62.6°

T_{md}=2.5° + 62.6° = 65.1

By use of Equation (1) and the data in Steps VII and VIII, estimates of the most probable temperature at the designated depths for each month of the year can be computed and tabulated as follows:

Month / Depth	Feb	Mar	Apr	May	Jun	Jul	Sep	Oct	Nov	Dec
Surface	62.7	65.4	69.7	74.3	80.7	82.0	83.0	77.5	70.5	65.4
10 feet	62.8	65.4	69.4	74.2	80.4	81.7	82.7	77.3	70.4	65.4
20 feet	62.9	65.4	69.5	73.9	79.9	81.2	82.2	76.9	70.3	65.4
30 feet	63.0	65.4	69.3	73.4	79.2	80.3	81.2	76.3	70.0	65.4
50 feet	62.9	65.1	68.4	72.1	77.3	78.2	79.0	74.6	69.1	65.0
70 feet	63.1	64.5	67.7	70.7	74.9	75.8	76.4	72.8	68.2	64.8
100 feet	62.9	64.0	65.9	67.9	70.6	71.2	71.6	69.2	66.2	64.0
150 feet	63.4	64.3	65.7	67.1	69.2	69.6	69.9	68.2	65.9	64.3
180 feet	63.6	64.4	65.7	67.1	69.0	69.4	69.7	68.1	66.0	64.4

STEP X

Since the (T_{ms}) or (T_w) represents the surface temperature at a point nearshore, corrections are presented in Tables IX, X, XI, and XII to obtain the surface temperature (Tw_{30}) above the 30-fathom isobath. These corrections are based on limited data and presented to show an "order of magnitude" of horizontal gradients of temperature in each of the four climate classes. Where the 30-fathom isobath is more than 10 miles offshore, the correction at 10 miles is suggested as an approximation of that at 30 fathoms.

CONCLUSIONS AND COMMENTS

This is a preliminary report primarily directed at presenting a method of classifying harbors and nearshore areas with respect to water temperatures. The secondary objective is to present a way of estimating the most probable temperatures and thermal structures in the various categories.

One of the shortcomings in this report is the quantity of data used in the preparation of Tables I through XII. Data in the form needed to compile such tables are difficult to obtain. The observations used were taken at various and unknown stages of tide, at various states of wind, wave, and turbulence conditions, at different locations with respect to river mouths, without regard to the volume of river discharge, under various bottom slope conditions which partially determine the volume of water exchanging energy with air, and without knowledge of the influence of internal waves.

It is apparent that larger samples are needed to mask some of these unknown influences inherent in these samples of data. Nevertheless, the data compiled for this study are presented as an approach to estimation of temperature values and thermal structure in the various categories of climate, tide range, and fresh water influence.

The tables in this report do not give any indication of diurnal temperature variations of the upper layers of the ocean. It is well known that these variations are small in the open ocean and that the variation is smallest in high latitudes and greatest in low latitude tropical waters. Diurnal variations in temperature decrease rapidly with depth and become generally insignificant below the surface. In shallow coastal and inland waters diurnal temperature variations are somewhat greater than in deep water, but in most instances the variations are less than 2° C. Leipper (Reference No. 14) and Laevastu (University of Hawaii, 1962) have shown special cases where rather large variations take place in tropical tidal pools or in an area where upwelling occurs in stratified (summer) water and tidal currents move over an irregular bottom. Leipper mentions changes of the order of 7 or 8 degrees Fahrenheit in the summer at Scripps Pier in California and Laevastu mentions changes in tropic waters in tidal pools of as high as 10 degrees Fahrenheit. Dietrich (Reference No. 7) discusses diurnal temperature variations in both deep and shallow water locations. The following summary shows values of diurnal temperature changes in water under several various conditions.

Source	Diurnal Variation (°C.)	Comments
The Oceans (Reference No. 20)	0.39 (Average)* 0.60 (Maximum)* 0.00 (Minimum)*	Observations in deep tropical water--overcast sky--moderate to fresh breeze.
	0.71 (Average)* 1.10 (Maximum)* 0.30 (Minimum)*	Observations from deep tropical waters--clear sky--moderate to fresh breeze.
	0.93 (Average)* 1.40 (Maximum)* 0.60 (Minimum)*	Observations from deep tropical waters -- overcast sky--calm or light breeze.
	1.59 (Average)* 1.90 (Maximum)* 1.20 (Minimum)*	Observations from deep tropical waters--clear sky -- calm to light breeze.
The Oceans (Reference No. 20)	0.2 to 0.3**	Deep water surface temperature observations in higher latitudes (Not the tropics).
"	0.4 to .06**	Diurnal variation at 50 meters.
The Oceans (Reference No. 20)	0.20 in December 0.69 in May	Average values at 44 stations around the British Isles in coastal waters.

*The numerical values given are believed to be somewhat in error; however, the influence of clouds and winds are evident. Cloudiness tends to decrease incoming radiation and reduces the amplitude of diurnal variation. Windiness tends to mix the surface layers distributing heat over a thicker layer, thereby reducing diurnal amplitudes in comparison with calm or light breeze conditions.

**The diurnal variation of sea temperature is so small that it is of little importance to the physical and biological processes in the sea. The small variations are essential to the study of heat exchange between air and water. (From "The Oceans")

Source	Diurnal Variation (°C.)	Comments
Defant (Reference No. 6)	0.4	Average surface variation in the open sea.
"	1.0	Value to which variations may rise in clear, calm weather over the open ocean.
"	2.0	Diurnal values may exceed this value in lakes away from the shore at the surface.
"	0.1	Diurnal variation at 4-6 meters in lakes away from the shore.
"	0.87	Surface variation in the Gulf of Trieste (enclosed basin close to the land) .. MERZ (1911).
"	0.25 (Average) 0.16 to 0.40 (Range)	Surface diurnal variation from Meteor Expedition observations between latitudes 12 1/2°N. and 21 1/2°S.
"	.04 (Average) .03 to .09 (Range)	Diurnal variation at 50 meters - Meteor Expedition.
Dietrich (Reference No. 7)	0.22 (Mean) 0.30 (Mean Maximum) (Summer)	North Sea--deep water. North Sea--deep water.
"	0.14 (Mean) 0.31 (Mean Maximum) (Summer)	Gulf of Finland--deep water. Gulf of Finland--deep water.
"	0.83 (Mean) 1.34 (Mean Maximum) (Summer)	Shallow water near Newquay England, Atlantic Ocean.

Source	Diurnal Variation (°C)	Comments
"	0.56 (Mean) 0.94 (Mean Maximum) (Summer)	Shallow water--Irish Sea.
"	0.86 (Mean) 1.90 (Mean Maximum) (Summer)	Shallow water -- Gulf of Bothnia.

The reader is advised to consult references 4, 5, 6, 10, 11, 14, 16, 20, and 30 in the bibliography for physical explanations of the causes and effects of thermal processes between water and air and within the water. These references discuss these processes extensively but not completely.

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TABLE I

TROPICAL CLIMATE CLASS

LEGEND

LN: Low tidal range (<10 ft.), no fresh water influence.
HN: High tidal range ($\geqq$10 ft.), no fresh water influence.
LR: Low tidal range (<10 ft.), fresh water influence present.
HR: High tidal range ($\geqq$10 ft.), fresh water influence present.

$C_i = T_{wi} - T_{ai}$ = difference between air and water temperature (surface)

n = number of observations in class

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \qquad \bar{T}_a + \bar{C} = \bar{T}_w \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

MONTH		LN		HN		LR		HR	
Northern Hemisphere	Southern Hemisphere	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
JAN	JUL	+0.3	1.0	+1.2	0.2	+0.7	1.2	+0.2	2.3
FEB	AUG	+0.2	1.4	+1.0	0.1	+1.2	0.6	+0.9	0.7
MAR	SEP	0.0	1.6	+1.2	0.9	+0.5	0.4	+0.3	0.8
APR	OCT	-0.5	2.0	+1.5	0.5	+1.0	0	+1.1	0.9
MAY	NOV	-0.6	1.4	+1.9	0.9	+0.7	1.3	+0.9	1.4
JUN	DEC	-0.5	1.7	+2.4	0.4	+1.0	2.2	+0.9	0.8
JUL	JAN	-0.2	1.8	+1.9	0.9	+0.8	1.2	+1.0	1.1
AUG	FEB	-0.1	1.4	+1.8	0.2	+1.0	0.8	+0.6	1.5
SEP	MAR	+0.6	1.5	+1.9	0.9	+1.0	0.8	+0.7	1.4
OCT	APR	+0.8	1.2	+1.9	0.2	+1.0	1.1	+1.6	0.5
NOV	MAY	+0.2	0.7	+1.6	0.1	+1.2	1.3	+1.3	0.6
DEC	JUN	+0.2	1.1	+1.7	0.4	+0.7	0.6	+0.7	1.0
		n=11		n = 2		n=3		n=5	

All values of $\bar{c}$ and σ_c are °F.

TABLE II

OCEANIC CLIMATIC CLASS

LEGEND

LN: Low tidal range (<10 ft.), no fresh water influence.
HN: High tidal range ($\geq$10 ft.), no fresh water influence.
LR: Low tidal range (<10 ft.), fresh water influence present.
HR: High tidal range ($\geq$10 ft.), fresh water influence present.

$C_i = T_{wi} - T_{ai}$ = difference between air and water temperature (surface)

n=number of observations in class

$$\bar{c} = \frac{\sum_{i=1}^{i=n} C_i}{n} \qquad \bar{T}_a + \bar{C} = \bar{T}_w \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

MONTH		LN		HN		LR		HR	
Northern Hemisphere	Southern Hemisphere	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
JAN	JUL	-0.1	1.3	+0.2	0.8	+0.1	0.9	+1.4	0.5
FEB	AUG	-0.6	1.0	+0.7	0.5	-0.5	1.5	+1.0	0.9
MAR	SEP	-0.9	1.1	-0.4	0.5	-0.2	0.5	+0.3	0.4
APR	OCT	-0.4	1.4	-0.2	0.2	-0.1	0.7	+1.0	0.1
MAY	NOV	-0.1	1.4	-0.5	0.4	-0.1	0.4	-0.5	1.2
JUN	DEC	-0.6	1.4	+0.1	1.2	-1.6	0.6	+0.5	0.4
JUL	JAN	-0.7	0.9	+0.3	0.9	-1.6	2.0	+1.1	0.8
AUG	FEB	0	1.5	+0.8	0.9	-0.9	1.4	+0.7	1.0
SEP	MAR	+0.4	1.3	+1.1	0.7	-0.3	0.6	+1.7	1.0
OCT	APR	+0.5	1.2	+0.6	1.0	+1.0	0.7	+1.4	2.2
NOV	MAY	+0.6	1.6	+0.4	1.2	+0.7	0.8	+1.4	0.5
DEC	JUN	+0.1	0.8	+1.0	1.1	-0.5	1.1	+1.4	1.3
		n=10		n=3		n=4		n=3	

All values of $\bar{c}$ and σ_c are °F.

TABLE III

SUB-CONTINENTAL CLIMATE CLASS

LEGEND

LN: Low tidal range (<10 ft.), no fresh water influence.
HN: High tidal range (≥10 ft.), no fresh water influence.
LR: Low tidal range (<10 ft.), fresh water influence present.
HR: High tidal range (≥10 ft.), fresh water influence present.

$C_i = T_{wi} - T_{ai}$ = difference between air and water temperature (surface)

n=number of observations in class

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \qquad \bar{T}_a + \bar{C} = \bar{T}_w \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

MONTH		LN		HN		LR		HR	
Northern Hemisphere	Southern Hemisphere	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
JAN	JUL	+4.1	3.5	+1.3	2.3	+2.3	3.7	+1.9	2.7
FEB	AUG	+2.8	2.9	+1.1	1.7	+2.7	4.6	+1.4	2.4
MAR	SEP	+0.7	3.1	+0.1	1.6	+1.4	5.5	+0.3	2.2
APR	OCT	-0.4	3.1	-0.4	1.8	-0.1	3.3	-1.2	1.9
MAY	NOV	-0.6	2.5	-1.4	1.9	-0.9	2.8	-1.4	1.9
JUN	DEC	-0.9	2.0	-0.8	2.1	-1.1	3.2	-0.5	1.9
JUL	JAN	-0.8	1.9	-1.5	1.6	0.0	2.7	-0.8	1.5
AUG	FEB	+0.1	1.8	-0.4	1.3	+0.9	3.0	0.0	1.6
SEP	MAR	+0.9	1.9	+0.1	1.6	+0.5	2.1	-0.4	1.0
OCT	APR	+0.7	5.5	+0.5	1.2	+0.5	2.0	+0.5	1.3
NOV	MAY	+2.9	3.1	+2.2	1.6	+2.5	2.5	+1.5	1.9
DEC	JUN	+4.1	3.7	+1.6	1.8	+2.4	3.4	+1.6	2.2
		n=87		n=11		n=14		n=10	

All values of $\bar{c}$ and σ_c are °F.

TABLE IV

CONTINENTAL CLIMATE CLASS

LEGEND

LN: Low tidal range (<10 ft.), no fresh water influence.
HN: High tidal range ($\geqq$10 ft.), no fresh water influence.
LR: Low tidal range (<10 ft.), fresh water influence present.
HR: High tidal range ($\geqq$10 ft.), fresh water influence present.

$C_i = T_{wi} - T_{ai}$ = difference between air and water temperature (surface)

n = number of observations in class

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \qquad \bar{T}_a + \bar{C} = \bar{T}_w \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

MONTH		LN		HN		LR		HR	
Northern Hemisphere	Southern Hemisphere	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
JAN	JUL	+10.4	6.1	+8.3	4.1	+10.4	7.1	+14.0	8.1
FEB	JUL	+8.9	7.3	+5.8	7.7	+9.0	8.2	+9.5	10.8
MAR	SEP	+5.2	8.0	+2.5	6.1	+6.0	8.0	+7.5	8.7
APR	OCT	+1.1	6.6	+0.4	4.5	+2.3	6.9	+4.5	4.9
MAY	NOV	-1.5	4.5	-2.4	1.1	+0.1	5.6	+2.0	3.5
JUN	DEC	-1.9	4.7	-6.8	3.5	-2.6	4.0	-0.8	3.0
JUL	JAN	-2.1	4.2	-5.2	4.6	-2.9	3.8	-0.9	0.8
AUG	FEB	-0.9	2.8	-4.2	4.3	-0.9	4.1	-0.4	1.7
SEP	MAR	+2.3	2.7	+2.8	2.5	+1.9	4.1	-0.7	2.5
OCT	APR	+3.6	4.9	+2.5	3.9	+4.2	4.6	+1.5	5.9
NOV	MAY	+6.4	5.4	+7.3	4.8	+7.7	6.0	+3.8	4.4
DEC	JUN	+9.4	6.4	+10.2	3.0	+10.3	6.9	+11.8	9.3
		n= 42		n= 5		n= 21		n= 3	

All values of $\bar{c}$ and σ_c are °F.

TABLE V

VERTICAL THERMAL GRADIENTS
TROPICAL CLIMATE CLASS

LEGEND: T_s = Surface water temperature as determined from Tables I through IV

T_d = Water temperature at designated depths

$C_i = T_{d_i} - T_{s_i}$

n = number of observations

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \qquad \bar{T}_d = \bar{T}_s + \bar{C}\ ; \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

LN: Tidal range less than 10 feet; fresh water influence absent.
HN: Tidal range equal to or greater than 10 feet; fresh water influence absent.
LR: Tidal range less than 10 feet; fresh water influence present.
HR: Tidal range equal to or greater than 10 feet; fresh water influence present.

WINTER (coldest month)

	LN		HN		LR		HR	
	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
Surface	0	0	0	0	0	0	0	0
10 feet	-0.2	0.3	0	0.0	-0.5	0.7	0	0.0
20 feet	-0.3	0.4	-0.1	0.1	-0.8	0.8	0	0.2
30 feet	-0.4	0.6	-0.1	0.1	-1.0	1.0	-0.3	0.7
50 feet	-0.6	0.8	-0.2	0.3	-1.0	1.0	0	0.5
70 feet	-0.8	1.1	-0.3	0.5	-1.1	1.1	+0.1	0.6
100 feet	-0.8	1.4	-	-	-2.7	1.2	-0.1	0.1
150 feet	-1.3	1.8	-	-	-3.1	-	-0.1	0.1
180 feet	-1.7	2.1	-	-	-2.8	-	-0.6	0.6
	n = 9		n = 3		n = 5		n = 5	

All values of $\bar{c}$ and σ_c are °F.

TABLE V (cont'd)

SUMMER (warmest month)

	LN		HN		LR		HR	
	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
Surface	0	0	0	0	0	0	0	0
10 feet	-0.2	0.3	0	0.0	-0.3	0.3	-0.2	0.1
20 feet	-0.5	0.7	0	0.0	-0.4	0.4	-0.6	0.8
30 feet	-0.8	0.9	-0.2	0.2	-0.8	0.5	-0.8	1.0
50 feet	-1.0	1.0	-1.0	0.8	-1.9	1.6	-1.1	1.0
70 feet	-1.5	1.3	-1.6	1.7	-2.5	2.2	-1.3	1.1
100 feet	-1.5	1.0	-2.3	2.6	-6.2	-	-1.5	1.1
150 feet	-2.6	1.5	-7.1	4.8	-5.2	-	-1.8	1.0
180 feet	-3.2	1.8	-9.8	7.8	-6.8	-	-2.4	1.6
	n = 9		n = 3		n = 5		n = 3	

All values of $\bar{c}$ and σ_c are °F.

TABLE VI

VERTICAL THERMAL GRADIENTS
OCEANIC CLIMATE CLASS

LEGEND: T_s = Surface water temperature as determined from Tables I through IV

T_d = Water temperature at designated depths

$$C_i = T_{d_i} - T_{s_i}$$

n = number of observations

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \qquad \bar{T}_d = \bar{T}_s + \bar{C} \;; \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

LN: Tidal range less than 10 feet; fresh water influence absent.
HN: Tidal range equal to or greater than 10 feet; fresh water influence absent.
LR: Tidal range less than 10 feet; fresh water influence present.
HR: Tidal range equal to or greater than 10 feet; fresh water influence present.

WINTER (coldest month)

	LN		HN		LR		HR	
	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
Surface	0	0	0	0	0	0	0	0
10 feet	-0.1	0.1	0.1	0.3	-0.9	0.4	-0.2	0.0
20 feet	-0.1	0.2	0.2	0.6	-1.7	0.7	-0.3	0.1
30 feet	-0.3	0.3	0.1	0.7	-	-	-0.7	0.4
50 feet	-0.6	0.6	-0.3	1.3	-2.0	-	-1.0	0.4
70 feet	-1.1	1.2	-0.2	1.4	-2.5	-	-1.1	0.2
100 feet	-2.4	3.9	-0.1	1.6	-3.0	-	-1.4	0.2
150 feet	-3.3	6.0	-0.3	2.1	-3.5	-	-	-
180 feet	-4.4	7.0	-	-	-4.0	-	-	-
	n = 10		n = 3		n = 2		n = 3	

All values of $\bar{c}$ and σ_c are °F.

TABLE VI (cont'd)

SUMMER (warmest month)

	LN		HN		LR		HR	
	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
Surface	0	0	0	0	0	0	0	0
10 feet	-0.8	0.8	-0.1	0.3	-0.3	0.0	-0.3	0.2
20 feet	-2.0	2.1	-0.5	0.5	-0.9	0.2	-0.7	0.3
30 feet	-2.8	2.5	-1.0	0.9	-1.5	0.2	-1.4	0.5
50 feet	-4.5	3.9	-1.7	1.6	-2.5	-	-2.8	0.9
70 feet	-6.0	4.5	-3.2	3.0	-3.5	-	-4.4	1.5
100 feet	-6.9	4.3	-4.6	4.1	-4.5	-	-9.8	-
150 feet	-8.8	4.0	-5.5	4.8	-6.0	-	-	-
180 feet	-10.5	5.0	-8.1	3.9	-6.5	-	-	-
	n = 10		n = 3		n = 2		n = 3	

All values of $\bar{c}$ and σ_c are °F.

TABLE VII

VERTICAL THERMAL GRADIENTS
SUB-CONTINENTAL CLIMATE CLASS

LEGEND: T_s = Surface water temperature as determined from Tables I through IV

T_d = Water temperature at designated depths

$C_i = T_{d_i} - T_{s_i}$

n = number of observations

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \qquad \bar{T}_d = \bar{T}_s + \bar{C}\ ; \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

LN: Tidal range less than 10 feet; fresh water influence absent.
HN: Tidal range equal to or greater than 10 feet; fresh water influence absent.
LR: Tidal range less than 10 feet; fresh water influence present.
HR: Tidal range equal to or greater than 10 feet; fresh water influence present.

WINTER (coldest month)

	LN		HN		LR		HR	
	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
Surface	0	0	0	0	0	0	0	0
10 feet	0.0	0.4	0.0	0.0	0.1	0.3	0.1	0.1
20 feet	0.0	0.5	0.0	0.0	0.2	0.5	0.1	0.3
30 feet	0.0	0.8	0.0	0.0	0.3	0.7	0.1	0.4
50 feet	0.1	1.3	+0.1	0.3	0.3	1.0	0.4	0.7
70 feet	0.3	1.6	-0.1	0.9	0.5	1.5	0.4	1.5
100 feet	0.5	2.2	-0.9	1.9	0.4	1.7	1.1	1.7
150 feet	0.7	2.5	-0.6	-	1.0	1.2	1.3	2.2
180 feet	0.8	2.4	-	-	1.2	1.3	2.3	3.7
	n = 87		n = 7		n = 12		n = 8	

All values of $\bar{c}$ and σ_c are °F.

TABLE VII (cont'd)

SUMMER (warmest month)

	LN		HN		LR		HR	
	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c	$\bar{c}$	σ_c
Surface	0	0	0	0	0	0	0	0
10 feet	-0.4	0.5	-0.2	0.5	-0.4	0.7	-0.2	0.3
20 feet	-0.9	1.0	-0.7	1.0	-0.9	1.3	-0.6	0.5
30 feet	-1.6	1.7	-1.4	1.7	-1.9	2.2	-1.0	0.7
50 feet	-3.8	4.1	-2.8	4.1	-4.2	4.4	-2.0	0.7
70 feet	-6.3	5.8	-6.1	5.8	-7.0	6.5	-2.9	1.6
100 feet	-9.6	6.7	-7.7	6.6	-12.0	9.3	-5.6	3.5
150 feet	-12.7	7.4	-8.0	-	-13.8	9.1	-8.6	4.8
180 feet	-14.0	7.1	-9.0	-	-14.0	9.3	-9.4	5.4
	n = 87		n = 7		n = 12		n = 8	

All values of $\bar{c}$ and σ_c are °F.

TABLE VIII

VERTICAL THERMAL GRADIENTS
CONTINENTAL CLIMATE CLASS

LEGEND: T_s = Surface water temperature as determined from Tables I through VIII

T_d = Water temperature at designated depths

$C_i = T_{d_i} - T_{s_i}$ n= number of observations

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \qquad \bar{T}_d = \bar{T}_s + \bar{C} \; ; \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

LN: Tidal range less than 10 feet; fresh water influence absent.
HN: Tidal range equal to or greater than 10 feet; fresh water influence absent.
LR: Tidal range less than 10 feet; fresh water influence present.
HR: Tidal range equal to or greater than 10 feet; fresh water influence present.

WINTER (coldest month)

	LN		HN		LR		HR	
	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c
Surface	0	0	0	0	0	0	0	0
10 feet	0.0	0.3	0.3	0.5	0.0	0.3	0.0	0.0
20 feet	0.0	0.4	0.6	1.0	0.0	0.5	0.0	0.0
30 feet	0.0	0.5	0.8	1.3	0.0	0.7	0.0	0.0
50 feet	0.0	0.6	1.2	2.0	0.0	0.8	0.0	0.1
70 feet	0.1	0.9	1.3	2.1	0.1	1.0	0.1	0.1
100 feet	0.2	1.0	2.5	2.0	0.1	1.3	0.1	0.1
150 feet	0.5	1.1	-	-	0.1	1.7	0.1	0.1
180 feet	0.4	1.3	-	-	0.1	1.9	0.1	0.1
	n= 37		n= 4		n= 19		n= 3	

All values of $\bar{c}$ and σ_c are °F.

TABLE VIII (cont'd)

SUMMER (warmest month)

	LN $\bar{c}$	LN σ_c	HN $\bar{c}$	HN σ_c	LR $\bar{c}$	LR σ_c	HR $\bar{c}$	HR σ_c
Surface	0	0	0	0	0	0	0	0
10 feet	-1.1	1.2	-0.3	0.4	-1.0	1.3	-0.8	0.6
20 feet	-2.3	2.4	-0.7	0.8	-2.4	2.5	-1.8	1.3
30 feet	-3.7	3.1	-2.2	0.6	-6.6	7.2	-3.6	2.6
50 feet	-7.0	5.0	-4.1	2.4	-10.6	8.5	-5.7	4.0
70 feet	-10.8	6.8	-7.5	4.6	-11.7	7.9	-12.0	-
100 feet	-14.8	8.8	-10.6	5.0	-16.4	5.8	-16.0	-
150 feet	-17.9	9.0	-17.8	-	-17.7	4.8	-20.5	-
180 feet	-20.1	7.2	-17.8	-	-18.6	4.7	-22.0	-
	n= 37		n=4		n=19		n= 3	

All values of $\bar{c}$ and σ_c are °F.

TABLE IX

HORIZONTAL THERMAL GRADIENTS TROPICAL CLIMATE CLASS

Legend

WINTER	(Northern Hemisphere):	January-February-March
	(Southern Hemisphere):	July-August-September
SPRING	(Northern Hemisphere):	April-May-June
	(Southern Hemisphere):	October-November-December
SUMMER	(Northern Hemisphere):	July-August-September
	(Southern Hemisphere):	January-February-March
AUTUMN	(Northern Hemisphere):	October-November-December
	(Southern Hemisphere):	April-May-June

T_x = Surface water temperature at distance x offshore;

x=1,2,3 etc nautical miles.

T_w = Surface water temperature very nearshore.

$C_i = T_{xi} - T_{wi}$; n = number of observations

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \; ; \; \bar{T}_w + \bar{C} = \bar{T}_x \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	
Winter	+0.1	0.2	+0.1	0.2	+0.1	0.3	+0.1	0.3	+0.1	0.3	+0.1	0.3	+0.1	0.4	+0.1	0.4	+0.1	0.4	+0.1	0.4	N=2
Spring	+0.3	0.6	+0.5	1.2	+0.5	1.5	+0.5	1.7	+0.5	2.0	+0.5	2.2	+0.5	2.2	+0.5	2.2	+0.5	2.2	+0.5	2.2	N=3
Summer	−0.2	0.3	−0.3	0.4	−0.3	0.5	−0.5	0.7	−0.5	0.7	−0.6	0.7	−0.6	0.7	−0.6	0.7	−0.6	0.7	−0.6	0.7	N=6
Autumn	+0.1	0.4	+0.3	0.8	+0.4	1.1	+0.6	1.5	+0.6	1.5	+0.6	1.5	+0.6	1.5	+0.6	1.5	+0.6	1.5	+0.6	1.5	N=3
	1		2		3		4		5		6		7		8		9		10		

NAUTICAL MILES OFFSHORE (X)

All values of $\bar{c}$ and σ_c are °F.

TABLE X

HORIZONTAL THERMAL GRADIENTS
OCEANIC CLIMATE CLASS

Legend

WINTER	(Northern Hemisphere):	January-February-March
	(Southern Hemisphere):	July-August-September
SPRING	(Northern Hemisphere):	April-May-June
	(Southern Hemisphere):	October-November-December
SUMMER	(Northern Hemisphere):	July-August-September
	(Southern Hemisphere):	January-February-March
AUTUMN	(Northern Hemisphere):	October-November-December
	(Southern Hemisphere):	April-May-June

T_x = Surface water temperature at distance x offshore; x=1,2,3 etc nautical miles.
T_w = Surface water temperature very nearshore.

$C_i = T_{xi} - T_{wi}$; n = number of observations

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \; ; \; \bar{T}_w + \bar{C} = \bar{T}_x \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	$\bar{C}$	σ_c	
Winter	+0.2	0.3	+0.4	0.6	+0.6	1.0	+0.6	1.1	+0.8	1.4	+0.9	1.6	+0.9	1.7	+1.0	1.8	+1.0	1.9	+1.1	2.0	N=9
Spring	+0.1	0.5	+0.1	0.9	+0.2	1.2	+0.2	1.5	+0.2	1.8	+0.2	1.9	+0.3	2.0	+0.3	2.0	+0.4	2.1	+0.4	2.1	N=11
Summer	+0.3	0.4	+0.5	0.7	+0.6	1.0	+0.7	1.2	+0.9	1.4	+1.2	1.9	+1.3	2.0	+1.3	2.1	+1.3	2.3	+1.3	2.4	N=7
Autumn	+0.1	0.4	+0.3	0.9	+0.4	1.1	+0.5	1.2	+0.6	1.3	+0.6	1.4	+0.7	1.5	+0.7	1.6	+0.7	1.7	+0.8	1.8	N=12
	1		2		3		4		5		6		7		8		9		10		

NAUTICAL MILES OFFSHORE (X)

All values of $\bar{c}$ and σ_c are °F.

TABLE XI

HORIZONTAL THERMAL GRADIENTS
SUB-CONTINENTAL CLIMATE CLASS

Legend

WINTER	(Northern Hemisphere):	January-February-March
	(Southern Hemisphere):	July-August-September
SPRING	(Northern Hemisphere):	April-May-June
	(Southern Hemisphere):	October-November-December
SUMMER	(Northern Hemisphere):	July-August-September
	(Southern Hemisphere):	January-February-March
AUTUMN	(Northern Hemisphere):	October-November-December
	(Southern Hemisphere):	April-May-June

T_x = Surface water temperature at distance x offshore; x=1,2,3 etc nautical miles.

T_w = Surface water temperature very nearshore.

$C_i = T_{xi} - T_{wi}$; n = number of observations

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \; ; \; \bar{T}_w + \bar{C} = \bar{T}_x \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	
Winter	+0.4	0.3	+0.6	0.4	+0.8	0.7	+1.0	0.8	+1.3	1.0	+1.6	1.3	+1.7	1.5	+1.8	1.5	+1.9	1.5	+2.0	1.5	N=8
Spring	+0.2	0.5	+0.3	1.5	+0.3	1.6	+0.3	1.8	+0.3	2.0	+0.3	2.2	+0.3	2.3	+0.3	2.4	+0.3	2.5	+0.3	2.5	N=8
Summer	+0.4	0.8	+0.5	1.0	+0.5	1.2	+0.5	1.4	+0.5	1.9	+0.5	2.2	+0.6	2.3	+0.7	2.5	+0.8	2.6	+0.9	2.7	N=6
Autumn	0	0.2	0	0.4	0	0.6	0	0.8	0	1.0	0	1.2	−0.3	1.3	−0.3	1.5	−0.3	1.7	−0.3	1.7	N=6
	1		2		3		4		5		6		7		8		9		10		

NAUTICAL MILES OFFSHORE (X)

All values of $\bar{c}$ and σ_c are °F.

TABLE XII

HORIZONTAL THERMAL GRADIENTS
CONTINENTAL CLIMATE CLASS

Legend

WINTER	(Northern Hemisphere):	January-February-March
	(Southern Hemisphere):	July-August-September
SPRING	(Northern Hemisphere):	April-May-June
	(Southern Hemisphere):	October-November-December
SUMMER	(Northern Hemisphere):	July-August-September
	(Southern Hemisphere):	January-February-March
AUTUMN	(Northern Hemisphere):	October-November-December
	(Southern Hemisphere):	April-May-June

T_x = Surface water temperature at distance x offshore; x= 1,2,3 etc. nautical miles

T_w = Surface water temperature very nearshore.

$C_i = T_{xi} - T_{wi}$; n = number of observations

$$\bar{C} = \frac{\sum_{i=1}^{i=n} C_i}{n} \; ; \; \bar{T}_w + \bar{C} = \bar{T}_x \qquad \sigma_c = \sqrt{\frac{\sum_{i=1}^{i=n} (C_i - \bar{C})^2}{n}}$$

	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	$\bar{C}$	σ_C	
Winter	+0.2	0.1	+0.4	0.3	+0.6	0.4	+0.8	0.6	+1.0	0.9	+1.3	1.4	+1.5	1.4	+1.6	1.5	+1.8	1.6	+1.9	1.7	N=12
Spring	+0.4	0.4	+0.7	0.7	+0.9	1.1	+1.3	1.5	+1.7	1.8	+1.7	1.8	+1.8	1.8	+1.8	1.9	+1.8	1.9	+1.9	1.9	N=7
Summer	+0.1	0.1	+0.2	0.3	+0.3	0.5	+0.5	0.7	+0.6	0.8	+0.7	1.0	+0.9	1.2	+1.0	1.2	+1.1	1.4	+1.2	1.4	N=10
Autumn	0	0.1	0	0.2	0	0.3	0	0.4	0	0.5	0	0.6	0	0.6	0	0.7	0	0.7	0	0.8	N=7
	1		2		3		4		5		6		7		8		9		10		

NAUTICAL MILES OFFSHORE (X)

All values of $\bar{c}$ and σ_c are °F.

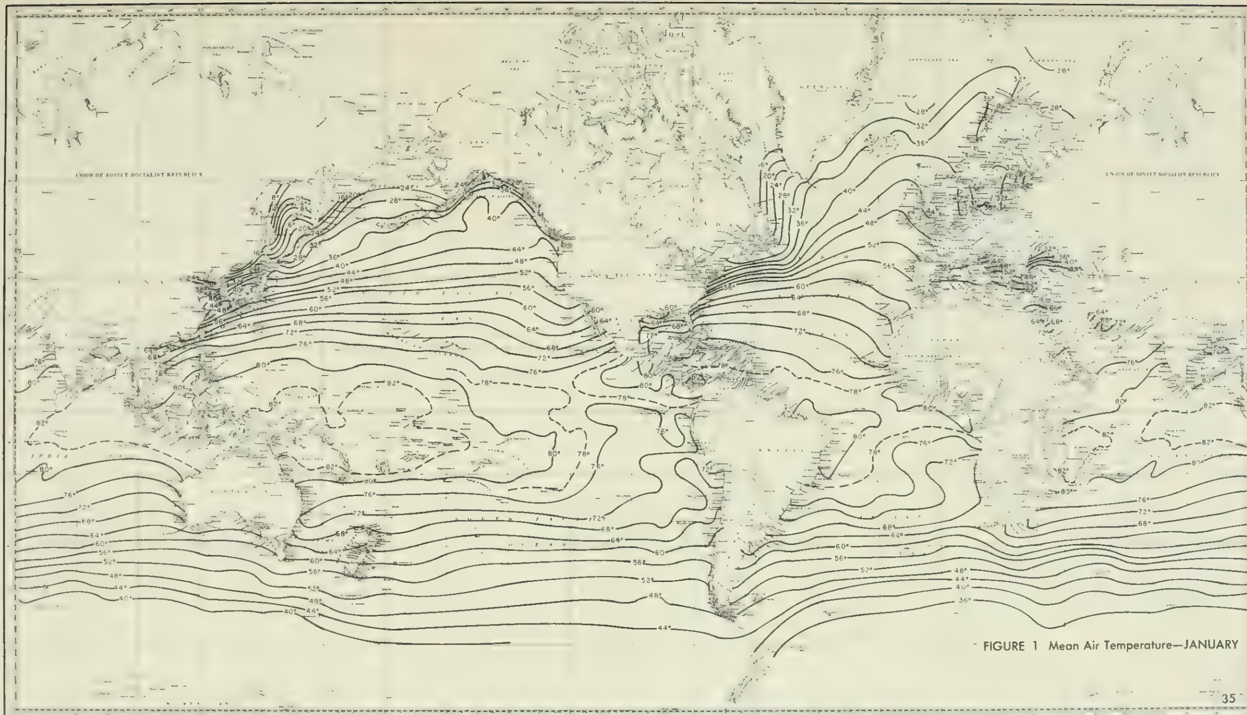

FIGURE 1 Mean Air Temperature—JANUARY

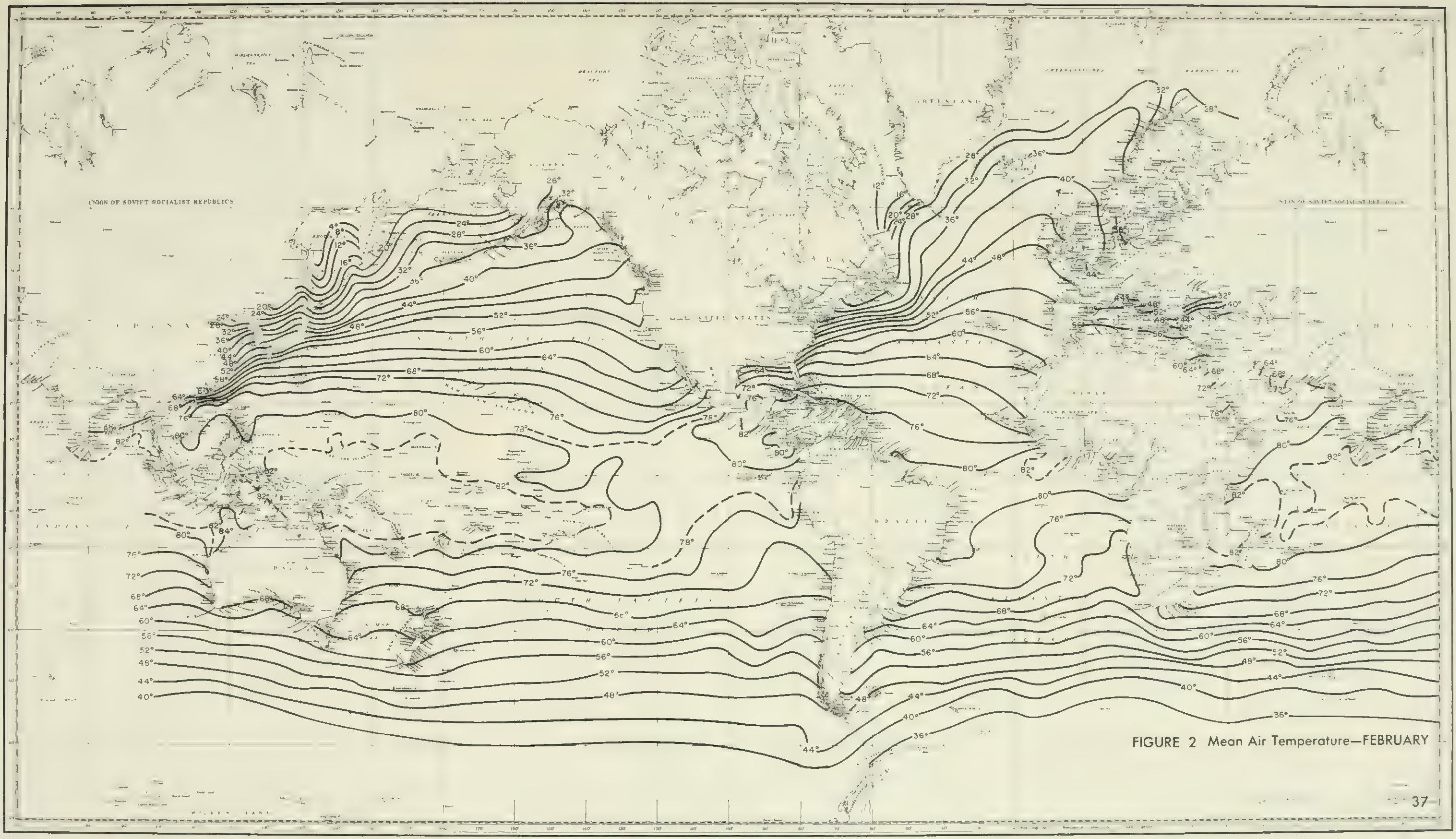

FIGURE 2 Mean Air Temperature—FEBRUARY

FIGURE 3 Mean Air Temperature—MARCH

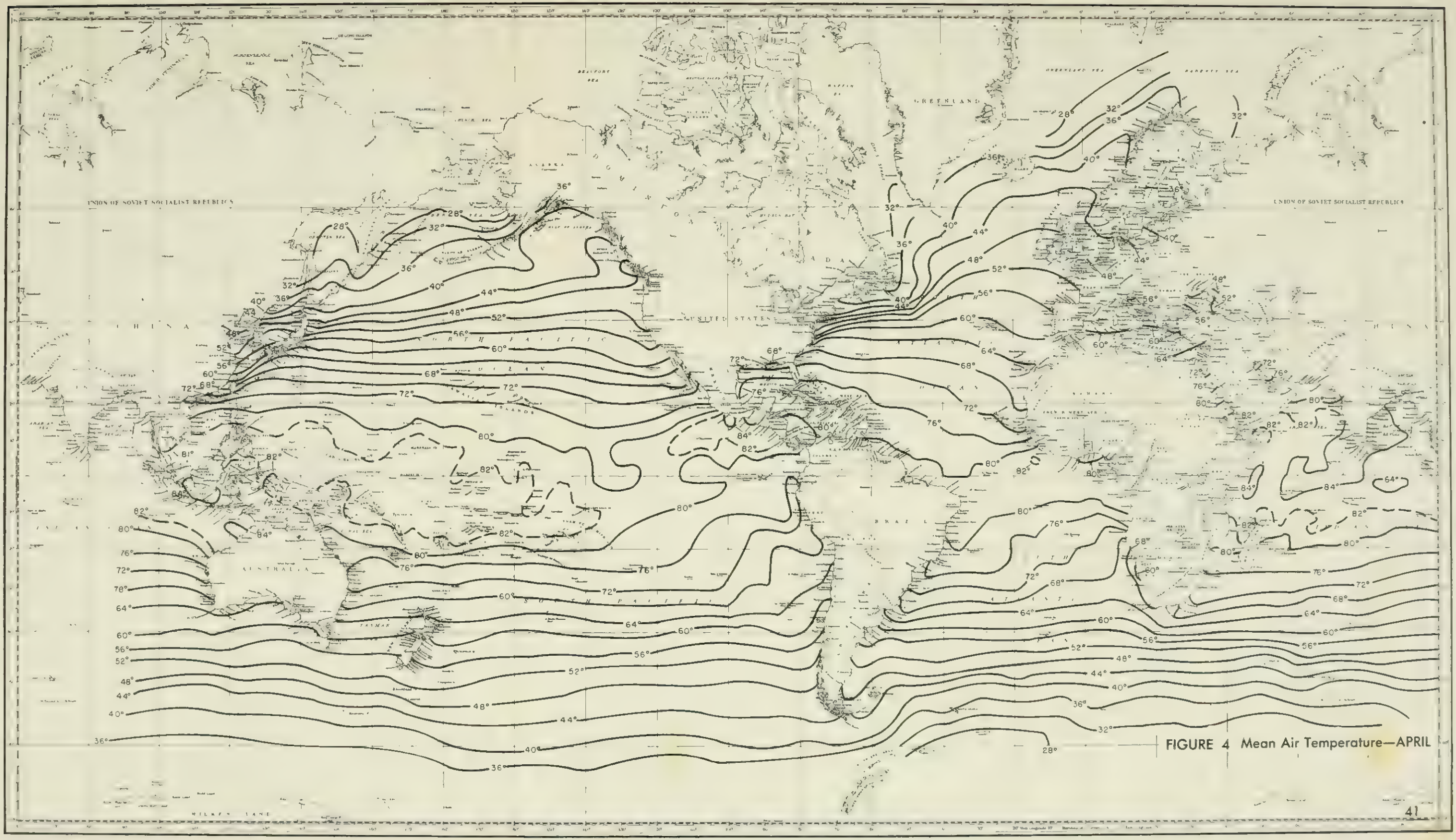

FIGURE 4 Mean Air Temperature—APRIL

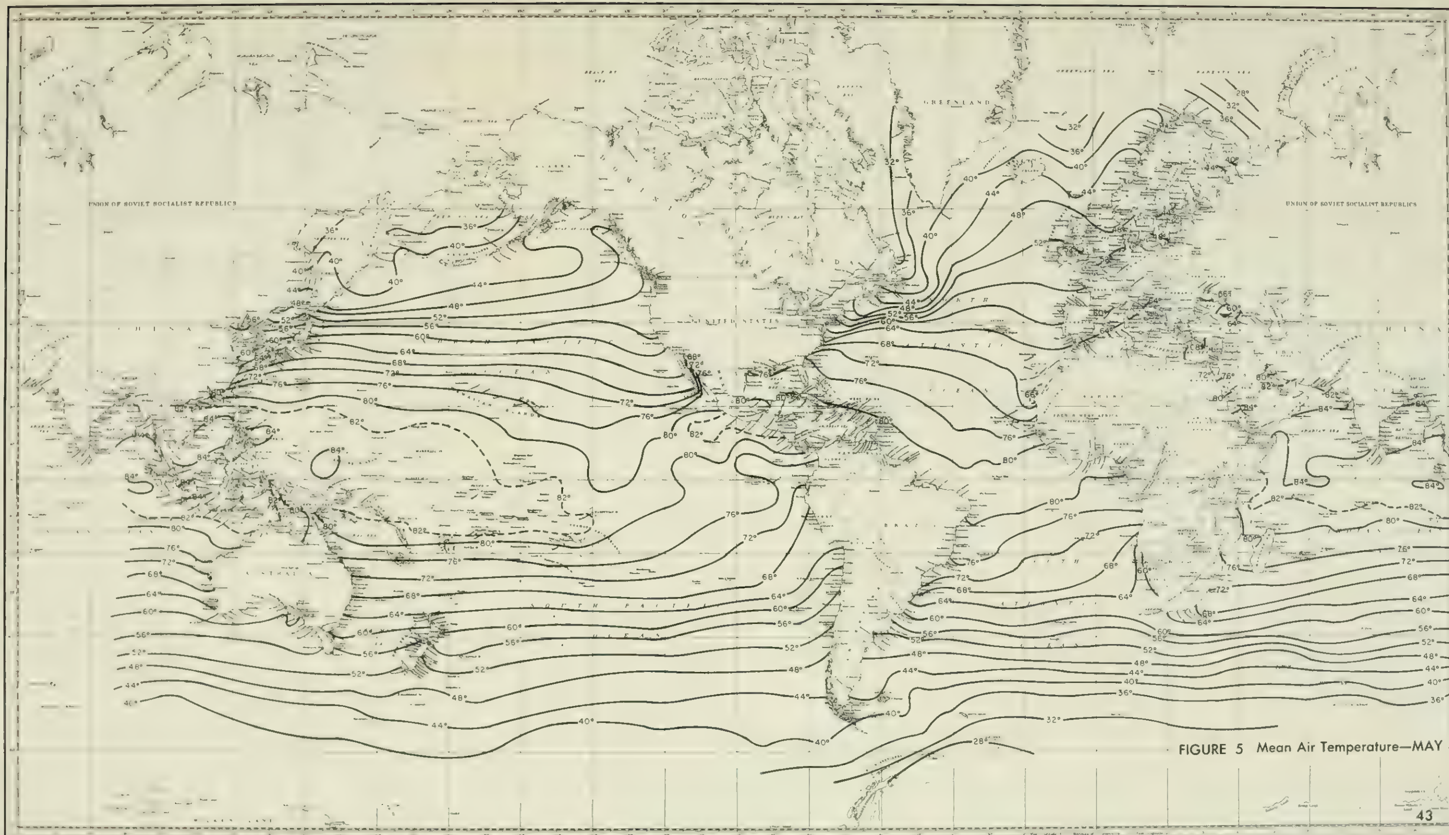

FIGURE 5 Mean Air Temperature—MAY

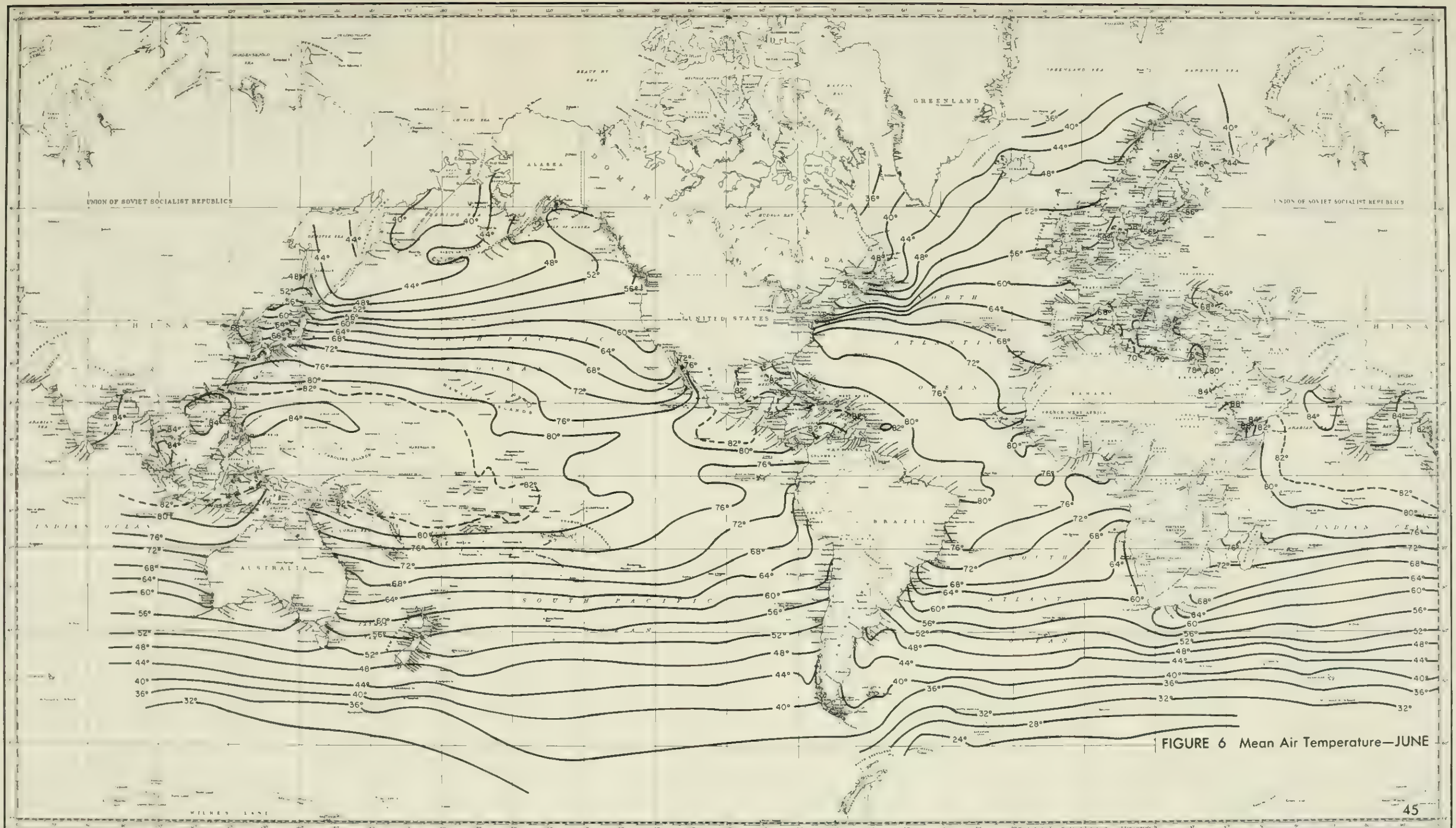

FIGURE 6 Mean Air Temperature—JUNE

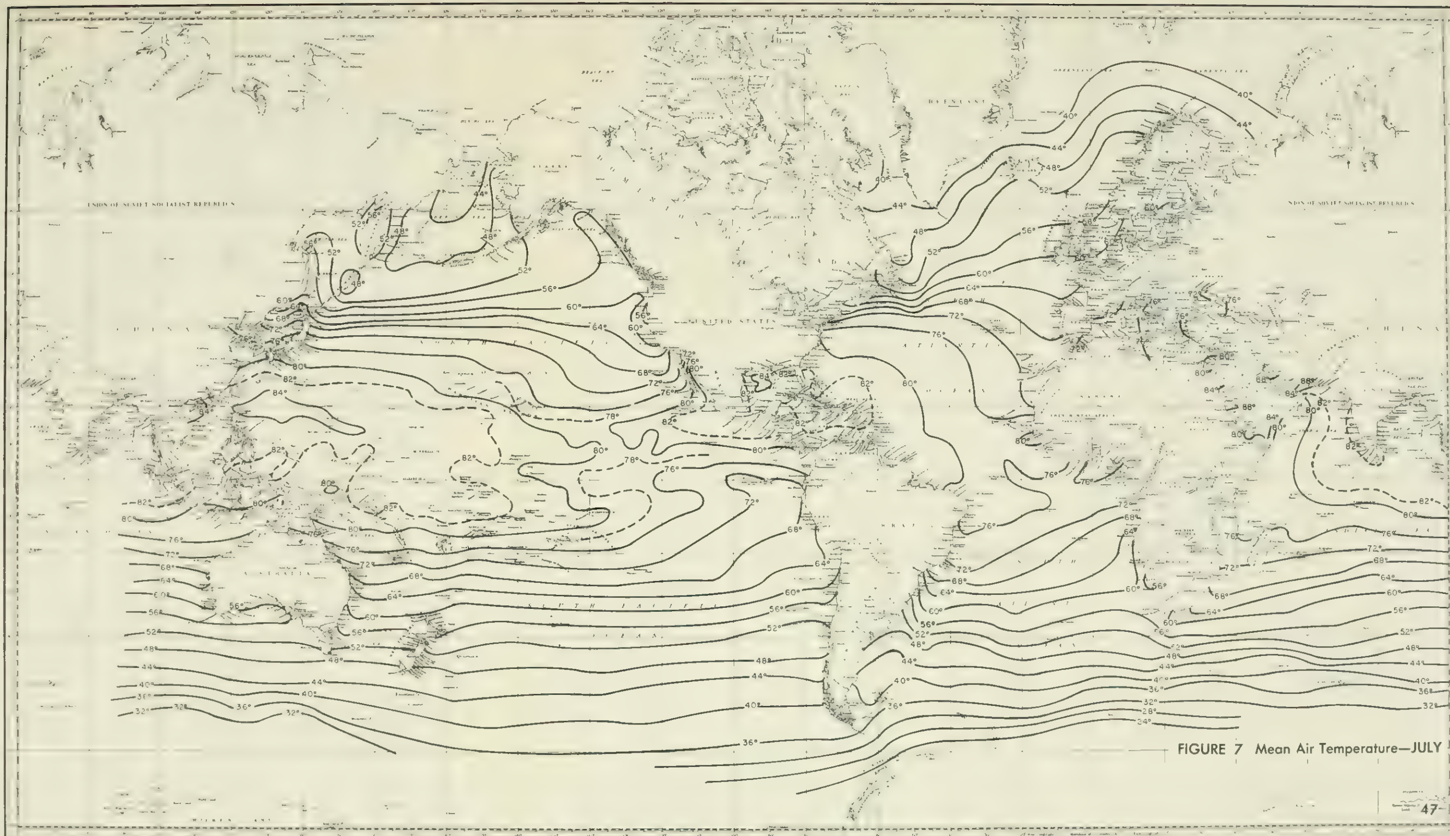

FIGURE 7 Mean Air Temperature—JULY

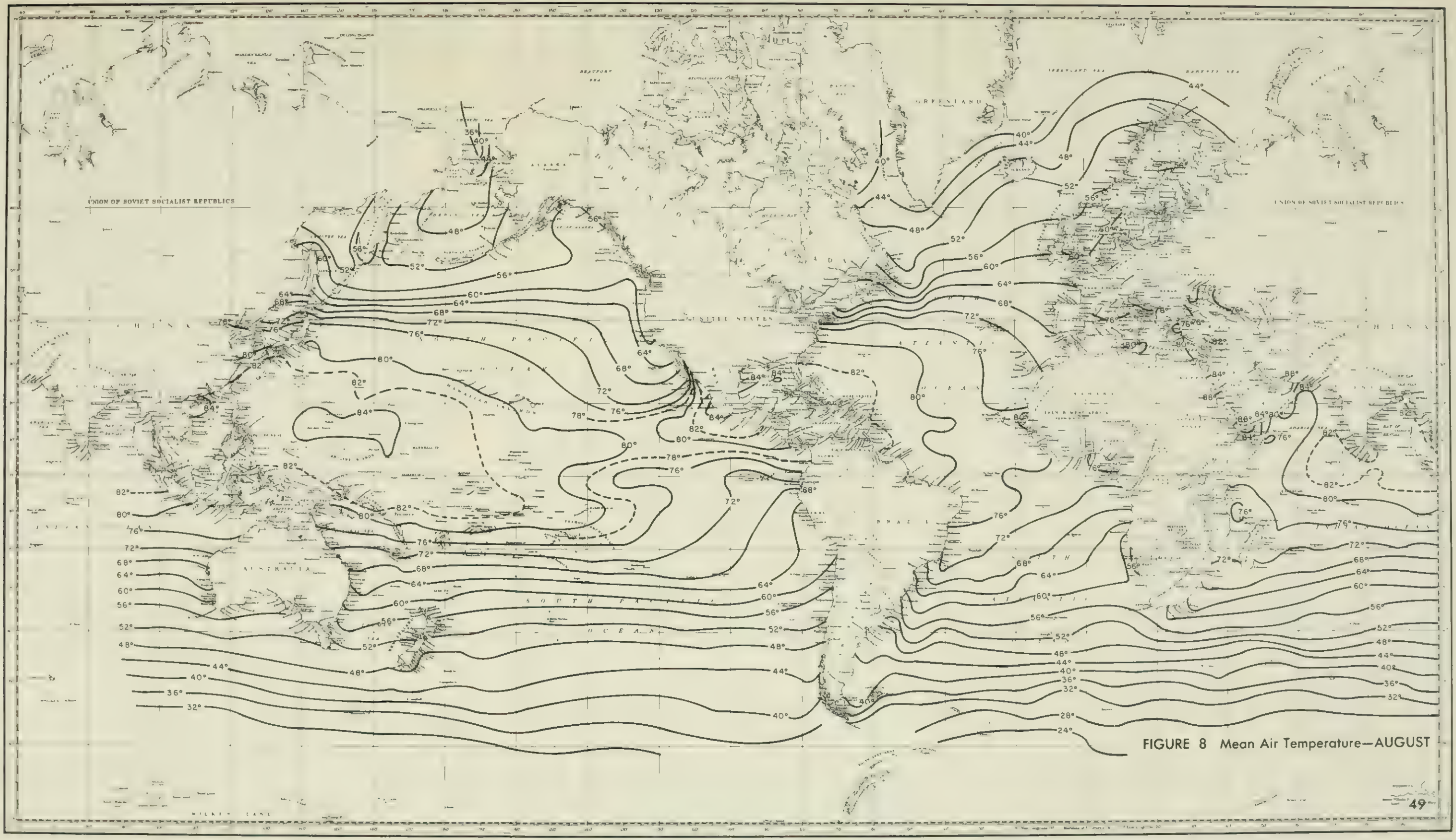

FIGURE 8 Mean Air Temperature—AUGUST

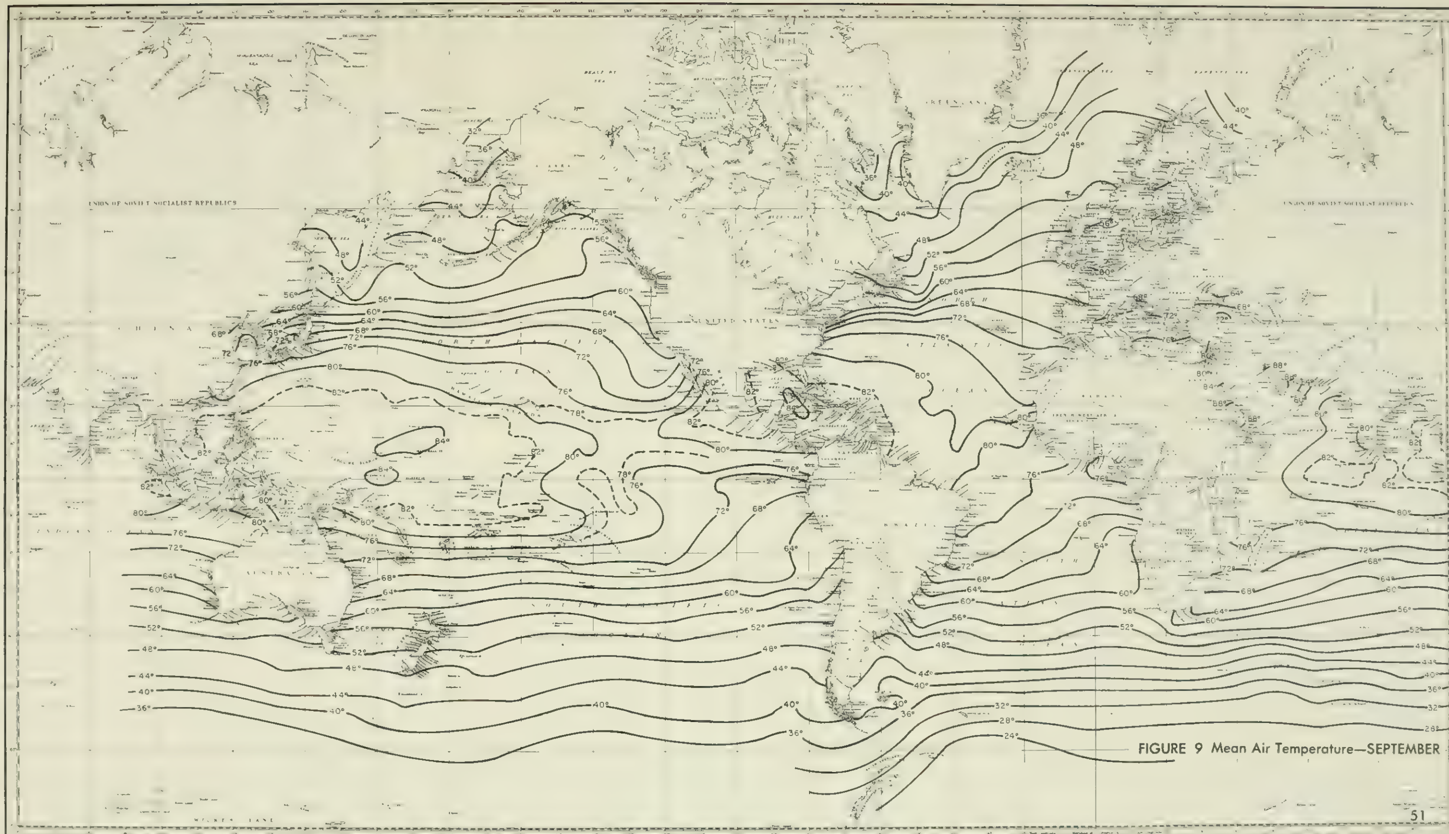

FIGURE 9 Mean Air Temperature—SEPTEMBER

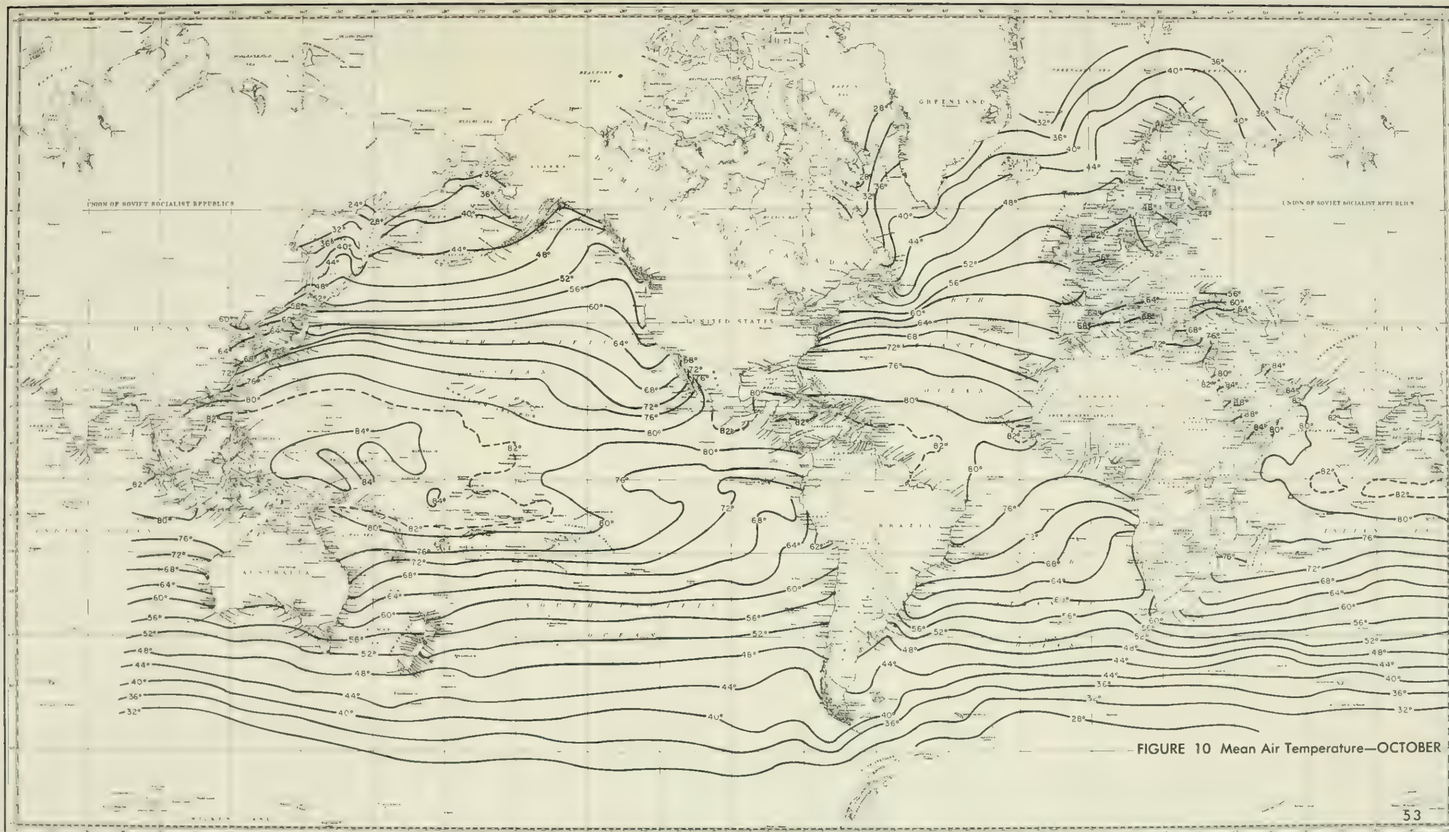

FIGURE 10 Mean Air Temperature—OCTOBER

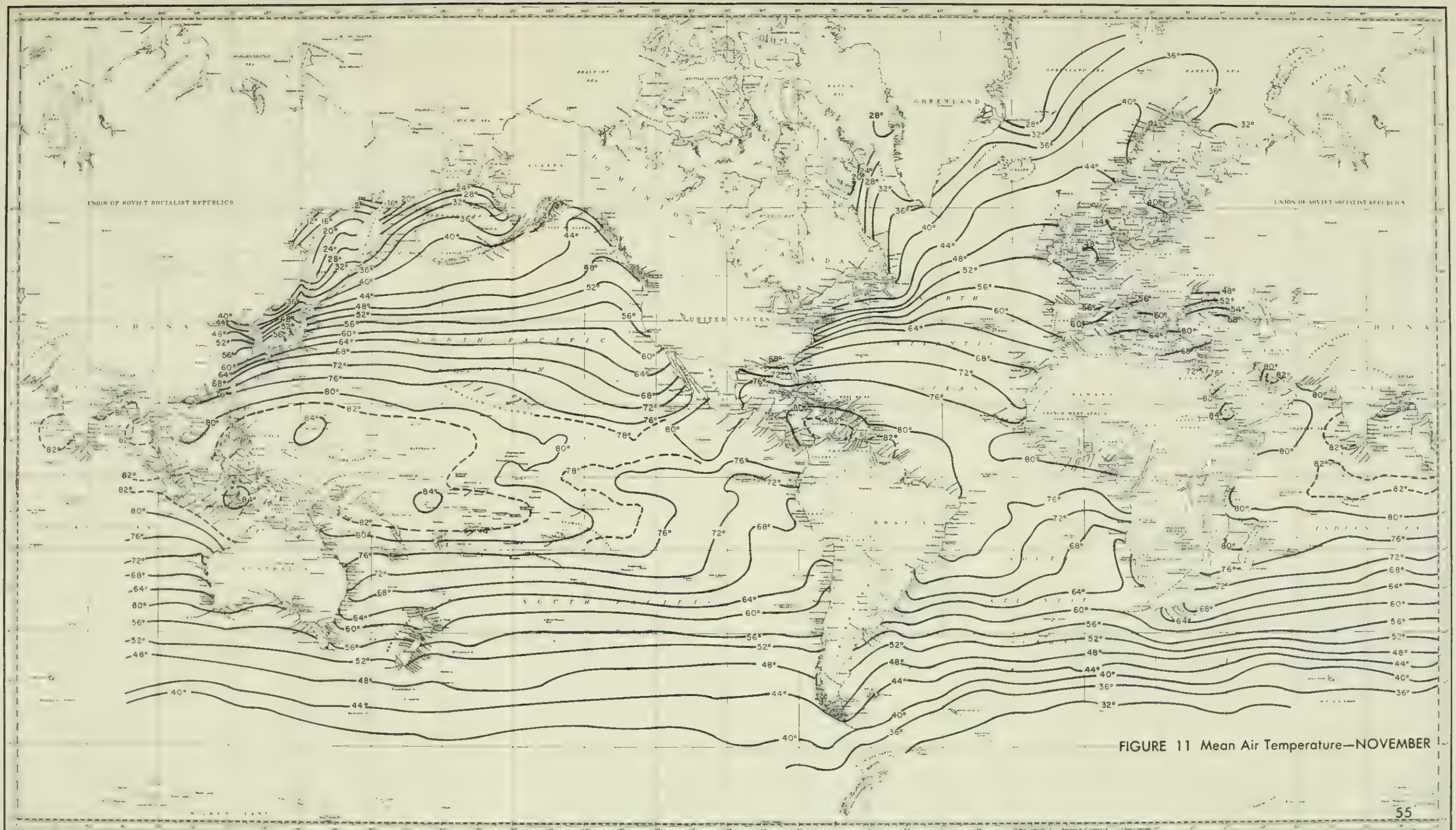

FIGURE 11 Mean Air Temperature—NOVEMBER

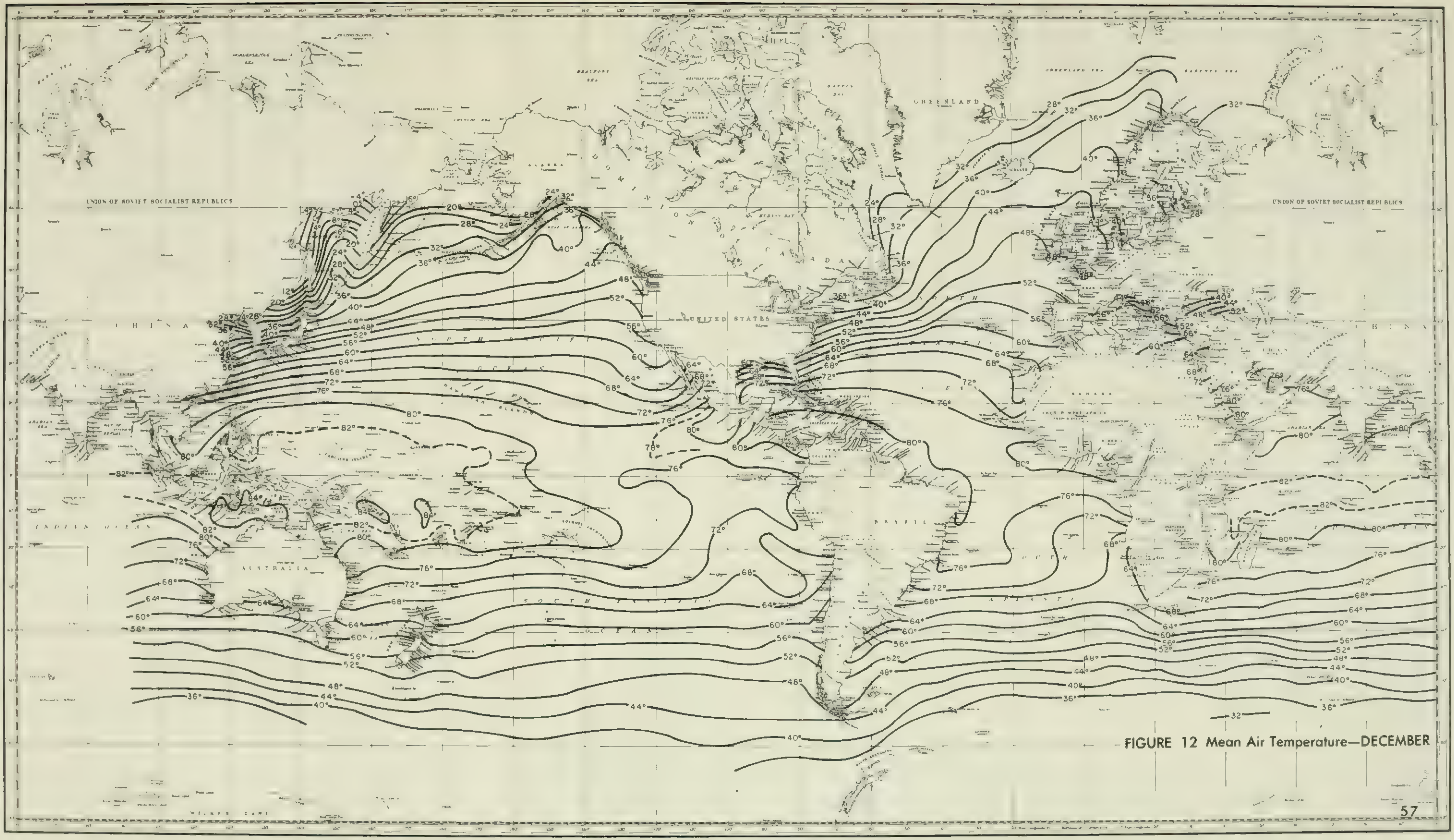

FIGURE 12 Mean Air Temperature—DECEMBER

FIGURE 13 MEAN MAXIMUM SEMI-MONTHLY TIDE RANGES

U. S. Naval Oceanographic Office
HARBOR ANALOG SYSTEM - Part II - TEMPERATURE STRUCTURE by A. L. Grabham, June 1963, 67 p. 13 figs. (TR-154)

This report classifies harbors and nearshore areas (30 fathoms shoreward) into analogous groups according to mean air and mean water temperature, tide ranges, and fresh water influence. Statistical predictions of surface air and water temperature as well as the vertical and horizontal gradients in the water from 30 fathoms shoreward are attempted. This is a preliminary report based on data from the U. S. Naval Oceanographic Office files.

1. Harbor Analog System - Part II Temperature Structure
2. Temperature - (Air-water-nearshore) Harbor Analog System

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ii. author: A. L. Grabham
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